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(71) Applicant: TRAKUS, INC. [US/US]; Suite 112, 35 Medford Street, Somerville, MA 02143 (US).

(72) Inventors: WADELL, Brian, C.; 73 Mount Vernon Street, Reading, MA 01867 (US). SPITZ, Eric; Apartment 24, 269 Harvard Street, Cambridge, MA 02139 (US). KATZ, David, J.; 2602 Village Road West, Norwood, MA 02062 (US).

(74) Agent: GIANNETTA, Michael, J.; Testa, Hurwitz & Thibeault, LLP, High Street Tower, 125 High Street, Boston, MA 02110 (US).

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(54) Title: PERFORMANCE MONITORING SYSTEM

(57) Abstract: The invention, in one embodiment, is directed to a performance measurement system comprising a first player-mounted device and a first field-positioned device. The first player-mounted device includes sensors adapted for automatically collecting sensor information from the first player, and a player transceiver adapted to wirelessly transmit and receive information. The first field-positioned device is adapted to be located in a first stationary position and includes, a field transceiver adapted to receive at least one of the first player sensor data and the performance parameters, and to transmit at least one of the performance parameters and messages to the first player-mounted device. In other embodiments, the system includes display devices and a central processor.

PERFORMANCE MONITORING SYSTEM

Field of the Invention

The invention relates generally to the field of performance monitoring. More specifically, the invention relates to systems and methods for monitoring player performance in sporting events and recreational activities.

Reference to Related Applications

This application claims priority to provisional U.S. patent application 60/141,484, filed on June 29, 1999. This application is a continuation-in-part of U.S. patent application 09/027,430, filed on February 20, 1998, which itself claims priority to provisional U.S. patent application number 60/039,182, filed on February 27, 1997. This application is also a continuation-in-part of U.S. patent application 09/398,157, filed on September 16, 1999, which itself claims priority to provisional U.S. patent application number 60/100,716, filed on September 17, 1998. The entire disclosure of each of the above referenced applications is hereby incorporated by reference.

Background of the Invention

Devices such as timers are used to measure player performance in various sporting events. For example, runners use timers to measure their performance against previous performances, targeted or expected performance, and against other runners. Small digital timers are available which include the functionality of a stopwatch, as well as more advanced functions. Some of these advanced functions included measuring split times as well as elapsed time, displaying the time of day, providing a basic calculator, and providing alarm functions. Generally, these digital timers are embodied in a wristwatch worn by the player. To time an event, the player typically depresses protruding buttons on the watch. For example, to start the timer, the player depresses one

button. To stop the timer or record a split, the player depresses the same or another button. The user typically physically depresses buttons on the watch for the timer to function. This can lead to inaccurate time reporting since the player may depress a button too early or too late. Also, although the timers optionally show split times, the data is of limited usefulness. For example, no data relating to other players is available for display. Furthermore, typically, the functions of the digital timer are performed locally, and there is no remote access to the timer.

Advances in digital electronics have made it possible to design small advanced circuits, such as data storage cameras, phones, MP3 players, and computers that are embedded in digital wrist watches. Data storage circuits have been used, for example to store names, addresses, and telephone numbers. Other technological advances have provided wrist-worn heart rate monitors and global positioning system (GPS) receivers. GPS receivers track and display a player's position. However, that data is typically only available locally to the player. Also, conventional GPS tracking systems fail to track performance data automatically. Limited range two-way radios are available that can be worn on a player's arm. Recently, wireless telephones have been introduced that are also small enough to be worn by a player. These devices also fail to monitor player performance parameters.

Other advances include passive devices that identify runners or marathoners as they pass over active mats located throughout the course. Some of these devices are typically worn on the shoe and are detected by the mat as long as the device passes over the mat. This range is typically about one meter. One such device, also referred to as a tag, is used to time marathoners at different locations along a marathon route. A central computer individually identifies each tag. That identification is cross-referenced to the individual marathoner. Although useful by supporters to track the marathoner's position, this device fails to offer the individual marathoner any feedback regarding his performance, position in the race, or pulse rate, for example. Accordingly an object of the invention is to provide an improved player performance monitoring system that addresses deficiencies in conventional systems.

Summary of the Invention

Briefly, the invention is directed to a performance measuring system. In one embodiment the system of the invention includes player-mounted devices and a plurality of field-positioned devices that feed a central processor and data access or display devices. According to a further embodiment, the performance measuring system monitors the performance of virtually any participant in any type of sporting or recreational activity. Illustratively, according to a preferred embodiment, the system may be used to monitor the performance of people, animals or even vehicles (generally referred to as "players" or "track objects"). By way of example, monitored activities may include, running, skiing, swimming, baseball, hiking, sailing, rowing, basketball, hockey, ice skating, roller skating, skateboarding, soccer, football, tennis, boxing, martial arts, motor sports, horse racing, dog racing, track and field events, racquetball, squash, badminton, volleyball, tug-of-war, weight lifting, bodybuilding, paddleball, handball, and the like. In another example, the system is used to monitor a child's activity or position. Alternatively, the system is used to monitor a child's heart rate or other vital signs.

The player-mounted device contains circuitry that uniquely identifies the instance of the player-mounted device and storage for the user's identification. Circuitry provides for keeping track of time, measuring, storing and processing parameters, and circuitry to transmit and receive data between the device and the outside world. According to one embodiment, the player-mounted device includes sensors, a transceiver, an antenna, a processor, and a display.

A player-mounted device may be mounted in a variety of manners. By way of example, it can be mounted to a player's torso, head, neck, arm or leg. It may also be mounted to player apparel, such as a shirt, pants, glove, helmet, saddle, shoe, or the like. It may also be mounted to equipment, such as a goal, stick, racket, bat, ski, ski board, surf board, ice skate, roller skate, skateboard, puck, ball, or the like. It may also be mounted to a vehicle, such as a bicycle, motorcycle, car, airplane, boat, personal watercraft, snowmobile, or the like.

The sensors can be, for example, pulse rate sensors, blood pressure monitors, glucose monitors and accelerometers. Thus, each player-mounted device can monitor a variety of performance parameters of the player to which it is mounted. Parameters may include for example, heart rate, blood pressure, glucose level, speed, direction, acceleration, rotation, force of impact, elapsed time, split time, hang time in the air, ranking in a competition, position on a course, and the like. The data acquisition sensors collect some of the raw data needed to measure performance parameters. The player-mounted device collects other raw data by interacting with the field-positioned devices to track the time that it takes to travel between various field-positioned devices. In some embodiments, the player processor processes the raw data to determine the performance parameters for the player. In other embodiments, the field-positioned devices perform the processing of the raw data. As a player comes within communication range of a field-positioned device, the player transceiver wirelessly transmits either the raw data, the performance parameters, or some combination of each to the field-positioned device by way of the player antenna. According to one feature, the field-positioned device transmits the processed performance data back to one or more of the player-mounted devices. According to one aspect, the player display displays selected performance parameters of the player to which the device is mounted. According to another aspect, the player display displays selected performance parameters of other players. The displayed parameters may either be received from the field-positioned devices or derived internally. According to another feature, the player-mounted device may include a control/data input mechanism, such as a miniature keypad or one or more pushbuttons. Optionally, the player can enter initial conditions, change the information displayed, and/or request additional performance parameters from the field-positioned devices. Each player-mounted device can be programmed with a unique identification code, which can be transmitted to the field-positioned devices, so that the field-positioned devices can correlate each player-mounted device with a particular player and also identify from which player-mounted device it is receiving data.

Player-mounted device preferences and settings are programmed wirelessly through the data interface. Parameters such as race category (*e.g.*, Masters) are stored in the watch. Also, the users' preferences for the watch alarms, time of day, messaging, etc.

are programmed remotely through this interface. In another embodiment, the users' preferences are programmed locally in the player-mounted device. In yet another embodiment, the programming is done via an optional interface port on the player-mounted device.

The field-positioned devices are located proximate to the area of the activity being monitored. These devices are used as fixed position references, to receive data from the player-mounted devices, and to send data including setup information, time of day, messages, and race rank to the player-mounted devices. The field-positioned devices also collect data from the central processor reflecting activity at other field-positioned devices and messages that need to be sent. By way of example, the field-positioned devices may be located, for example, along the perimeter of a playing field, course, track, court, pool, arena, or the like. As skilled artisans will appreciate, the number of field-positioned devices depends at least in part on the size of the area of the activity.

Typically, the field-positioned device will transmit the time and other information to the player-mounted device which will then calculate its split and position in the race. The field-positioned devices operate autonomously and are typically administered remotely and therefore do not require a user interface (keyboard, mouse, and display). According to a further embodiment, the field-positioned devices include a processor, transceiver, antenna, display, keyboard/mouse, and memory. The transceiver enables the field-positioned device to wirelessly communicate with the player-mounted devices. Optionally, the field-positioned devices also wirelessly communicate with the central processor to synchronize timing signals and share player performance information. Communication from the field-positioned device to the central processor can occur with any of a variety of standard techniques used to communicate data among computers: Ethernet, IEEE 802.11 WLAN, fiber optics, IRDA, parallel and serial data, etc.

According to a further feature, the field-positioned devices may also include a global positioning satellite system (GPS) receiver to establish a common timing signal between the field-positioned devices. The GPS receiver may also be used to establish the precise position of the field-positioned devices.

According to another feature, the field-positioned devices include a wired or wireless communication link to the Internet so that the performance measurement system of the invention can post performance information, for either interested or paying parties, at a Web site. With such an Internet connection, the field-positioned devices can also relay communications received from the Internet to one or more of the player-mounted devices. Typically, administrator functions are accomplished remotely via the network connection from a central location.

In one preferred embodiment, a display is available for displaying performance information to event spectators, such as coaches, athletes, scouts, officials, or anyone observing the event, in substantially real-time. According to another feature, the field-positioned devices may include a user keyboard and display to enable fans to interact with the system and data or for a system administrator to configure and monitor the operation of each field-positioned device.

In some embodiments, the player positioning system includes a central processor, which may be used to configure the performance monitoring system, monitor its health, interface with data access and display devices, and to perform some or all of the processing of the data from the player-mounted devices. In one embodiment, the central processor assigns unique identification codes to each of the player-mounted devices. According to another embodiment, the player-mounted devices supply the central processor with their unique identification codes. Either way, the unique identification codes may be used to avoid communication collisions when the field-positioned devices communicate with the player-mounted devices.

According to a further feature, the field-positioned devices are in direct wireless communication with the central processor. Thus, the central processor can provide the field-positioned devices with unique identification codes of the player-mounted devices. Alternatively, the field-positioned devices can assign or collect the player-mounted device unique identification codes, and provide those codes to the central processor. According to another feature, the field-positioned devices use the wireless connection with the central processor to pass the raw data to the central processor. The central

processor processes the raw data and passes processed performance parameters back to the field-positioned devices. In some embodiments, the functionality of the central processor is incorporated into one or more of the field-positioned devices.

According to another embodiment, the performance monitoring system of the invention includes an Internet Web server computer, and the central processor includes an Internet connection for communicating with the Web server computer. Such communications may include providing performance parameters to the Web server computer and/or relaying messages between Internet users and the players by way of the field-positioned devices. By connecting to the Web server, interested or paying parties can gain access, download and print the performance parameters. The Web server computer can also make the performance parameters available to the players at the end of the monitored activity. According to another feature, the Web server enables players to register for particular activities by way of an Internet connection.

During setup the central processor or devices connected to it are used to transfer athlete preferences and race-specific setup information into the player-mounted device. According to one preferred embodiment, the data collected by the system from the players can be accessed by a variety of client devices for entertainment, training, or informational purposes. Such devices connect to the central processor to obtain data and present the data, for example, in the form of an Internet Web page, a television graphic, an interactive television feed to the home, a video game, or the like. These clients can also send data back to the central processor for forwarding to the player in the area of the activity. For example, a user at home might locate a friend running a marathon from a Web browser and then send an encouraging message to his/her player-mounted device.

As skilled artisans will appreciate, the invention also provides associated methods for the performing functions of the above briefly described performance monitoring system. Other features of the invention are discussed below in relation to the illustrative drawings.

Brief Description of the Drawings

Figure 1 is a conceptual block diagram depicting exemplary components of an illustrative performance monitoring system according to the invention;

Figure 2A is a conceptual diagram of one illustrative application of the performance monitoring system of Figure 1;

Figure 2B is a conceptual diagram of another illustrative application of the performance monitoring system of Figure 1;

Figure 2C is a conceptual diagram of another illustrative application of the performance monitoring system of Figure 1;

Figure 3 is a block diagram of an illustrative player-mounted device of the type employed in the performance monitoring system of Figure 1;

Figure 4A depicts an illustrative physical embodiment of the player-mounted device of Figure 3;

Figure 4B depicts an illustrative display portion of the player-mounted device of Figure 3;

Figure 4C depicts another illustrative display portion of the player-mounted device of Figure 3;

Figure 5 is a block diagram of an illustrative field-positioned device of the type employed in the performance monitoring system of Figure 1; and

Figure 6 is a block diagram of an illustrative central processor of the type optionally employed in the performance monitoring system of Figure 1.

Description of the Illustrative Embodiment

Figure 1 depicts a simplified block diagram of a performance measurement system 100 according to an illustrative embodiment of the invention. The illustrative

performance measurement system 100 includes a player-mounted device 102, and a field-positioned device 104. In an optional embodiment, the system further includes a central processor 106. The central processor 106, in an alternate embodiment, is integrated within the field-positioned device 104. Alternatively, the central processor 106 is further coupled to a network 105. The network 105 may be connected to various network devices including, a Web server 107, a Web client 109, a video game client 111, a wireless client 113, and a TV client 115. As described briefly above, the performance measurement system 100 can monitor the performance of people, animals or even vehicles (generally referred to as "players" or "track objects") in virtually any type of sporting or recreational activity.

In operation, the player-mounted device 102 mounts in any number of ways to a player, and collects raw data related to the player's performance and position. In the preferred embodiment, the player-mounted device 102 processes the raw collected data prior to transmission. This processing may include, for example, formatting the data for transmission, error-checking, or compressing the data. The field-positioned devices 104 are located proximate to and around or along the course of the sporting or recreational activity. In the preferred embodiment, the player-mounted device 102 receives time of day messages from field-positioned devices 104 and uses these to calculate splits and position in the race. The player-mounted device 102 receives setup and control messages by the same means. In the preferred embodiment the player-mounted device 102 additionally processes and packages identification code, sensor measurements, and other data and transmits it to a proximate field-positioned device 104. In another embodiment, the field-positioned device 104 acquires data including timing and position data related to a player or players.

In another illustrative operation, the player-mounted device 102 transmits raw data to the nearest field-positioned device 104. In alternative operation, the field-positioned device 104 processes the raw data to determine performance parameters and then transmits the performance parameters to the player-mounted device 102, or alternatively, to another field-positioned device 104. In another embodiment, the player-mounted device 102 preprocesses raw data before transmission. The preprocessing can

include, for example, data error correction, data formatting, data compression and the like. For example, the field-positioned device can hold advanced receiver, signal processing capabilities, and the more power hungry circuitry required to multilaterate the player-mounted device 102.

In response to receiving performance parameters, the field-positioned device can display select performance parameters for spectator viewing. The field-positioned device 104 can also transmit the performance parameters to the optional central processor 106. The central processor 106 optionally displays the performance parameters. Alternatively, the central processor 106 routes the data to the network 105. In illustrative embodiments, the network 105 is an Ethernet in a local area network or a wide area network. Optional network devices may be coupled to the network 105.

In response to receiving raw or preprocessed data, the field-positioned device 104 processes the data into performance parameters for storage, display, or analysis. Alternatively, the field-positioned device 104 displays selected parameters for spectator viewing and transmits at least some of the performance parameters back to one or more of the player-mounted devices 102. Alternatively, the field-positioned device 104 transmits the raw or preprocessed data to the central processor 106, which processes the data to determine the various performance parameters. The central processor 106 transmits the performance to one or more of the field-positioned devices 104 and/or one or more of the player-mounted devices 102.

In the illustrative embodiment, player-mounted device 102 passes a first field-positioned device 104. The field-positioned device 104 updates or refreshes the internal clock of player-mounted device 102. Additionally, the first field-positioned device 104 records the time the player-mounted device 102 reached it. The first field-positioned device 104 transmits that recorded time to the central processor 106. In one embodiment, the central processor knows the location of the first field-positioned device 104. In another embodiment, the first field-positioned device transmits location data to the central processor 106. The player-mounted device 102 then passes a second field-positioned device 104. The second field-positioned device 104 updates or refreshes the

internal clock of player-mounted device 102. Additionally, the second field-positioned device 104 records the time the player-mounted device 102 reached it. The second field-positioned device 104 transmits that recorded time to the central processor 106. In one embodiment, the central processor 106 knows the location of the second field-positioned device 104. In another embodiment, the second field-positioned device 104 transmits location data to the central processor 106. The central processor 106 then calculates the time elapsed between the player reaching the first field-positioned device 104 and the player reaching the second field-positioned device 104. The central processor 106 transmits the calculated data to the second field-positioned device 104. The second field-positioned device 104 transmits the calculated data to the player-mounted device 102.

In further operation, and as discussed in more detail below, the central processor 106 also provides the performance parameters to the network 105. The network 105 is optionally coupled to network devices. The network devices include, for example, a Web server 107. Another network device includes a Web client 109. A Web client 109 includes a computer with an Internet navigation program. Still another network device includes a video game client 111. The video game client 111 may include, for example, a computer-based client, a video game console, a portable video game, or a handheld video game. Yet another network device includes a wireless client 113. The wireless client 113 may include, for example, a personal digital assistant (PDA), a wireless telephone, a pager, or a two-way pager. Another network device includes a TV client 115. The TV client 115 includes, for example, enhanced TV, Web TV, or interactive TV. Additionally, a television broadcast company, such as a television network, could optionally download and broadcast performance data. Further clients may include, for example, a scoreboard indicator, a scoreboard graphical display, a printer, or the like. Operation of the system 100 is discussed in further detail below.

Figure 2A illustrates a conceptual diagram of the performance monitoring system 200 according to one embodiment of the present invention. The system 200 includes at least one player-mounted device 202. In one embodiment, the player-mounted device 202 is worn on the wrist of the player 216. In another embodiment, a device 202' comprising a transceiver is worn on the shoe or foot of the player 216. The player-

mounted device 202 comprises the transceiver circuitry as well as a visual display for viewing data. In an alternate embodiment, the player-mounted device 202 includes audio circuitry for generating sound. An audio transducer (beeper), earphones or a built-in speaker relay the sound data to the user. The sound data may be in the form of tones, spoken language or music, for example.

Figure 2A-2C also depicts various media 201 in which the event or activity is taking place. In alternative embodiments, the media 201, for example, is a field, a road, a track, a body of water, a ski slope, a desert, a forest, a wilderness, a beach, or the like. The performance monitoring system 200 further includes field-positioned devices 206 placed at various locations around or along the medium 201. In another embodiment, the field-positioned devices 206 are known as tower transceivers (TTs). The field-positioned devices 206 include transceiver circuitry as well as a processor and memory for data storage, manipulation and forwarding. In another embodiment, the field-positioned devices 206 include a display 212 adapted for viewing by the player 216. The display 212, in one embodiment, is a large screen display as is commonly used for scoring at events. In another embodiment, supporters can send messages to the player via the network 105 (e.g., from the Internet). The player 216 views the messages, along with her performance data, as she passes the display 212 or on the player-mounted device 202.

In one embodiment, the field-positioned devices 206 are located at regular intervals along the medium 201. In another embodiment, the field-positioned devices 206 are located at uneven intervals along the medium 201. In yet another embodiment, the field-positioned device 206 includes a sensor strip 204 located on the medium 201. The players 216 pass over the sensor strip 204 during the event. When the players 216 with a player-mounted device 202 come within range of a field-positioned device 206, data is transmitted between the player-mounted device 202 and the field-positioned device 206. In another embodiment, the field-positioned device 206 includes an antenna 208 for transmitting and receiving data. In yet another embodiment, the field-positioned device 206 is a fixed transceiver 214. The tower transceiver 214 is substantially a permanent fixture including a transceiver, an antenna 208, and a connection to the network 105 of Figure 1.

The signal transmitted by the player-mounted device 202 to the field-positioned device 206 includes a unique identifier of the player-mounted device 202, identification of the player 216 and his race category, splits, and measured parameters such as *x,y,z* location, heart rate, blood pressure, ambient temperature, arm speed, or bat speed, for example. The data transmitted by the field-positioned device 206 to the player-mounted device 202 includes time of day, elapsed time, runners that have passed already, interval or split time, pace, distance traveled, distance left in event, calories burned, distance to next refreshment, and position in race, for example.

In another embodiment, the field-positioned device 206 is mounted in a moving vehicle 210. The moving vehicle 210 is a car, truck, van, motorcycle or any vehicle for mounting the field-positioned device 206. In one embodiment, the moving vehicle follows the player 216 and the location of the vehicle 210 is found by GPS or similar system. This embodiment wirelessly provides a virtually continuous update of player position over large geographical areas. In another embodiment, several vehicles 210 are stationed along the route. After the last player 216 passes the stationary vehicle 210, it moves to another location in the route. By utilizing several vehicles 210, fewer field-positioned devices 206 are required to monitor a race, for example.

In one embodiment, the player-mounted device 202 includes a GPS circuit which receives signals from the GPS satellites 218. The GPS circuit along with the field-positioned devices 206, generate precise position information of each player 216. Processing can take place in the player-mounted device 202 or the signal can be transmitted to a field-positioned device 206 for more powerful processing with the benefit of not loading the player-mounted battery 202.

An optional embodiment of the system 200 includes a central processor 203. The central processor 203 comprises an antenna 211, a transceiver, a processor, and a database, for example. In one embodiment, the central processor 203 programs each of the player-mounted devices 202 with a unique identifier. In another embodiment, the central processor 203 initializes and synchronizes the field-positioned devices 206. In yet another embodiment, the central processor 203 comprises a database which includes all

of the data relating to the players 216 and the event. The central processor 203 further includes a processor 207 for processing and retrieving data from the database 213. In another embodiment, the central processor 203 receives data from the field-positioned devices 206 through an antenna 211. The antenna 211 is coupled to a transceiver. The transceiver is adapted to receive and route data to the processor 207. In another embodiment, the transceiver 209 transmits data from the processor 207 to the field-positioned devices 206. In alternate embodiments, the processor is a PC-based computer, a workstation, or a server, for example. In another embodiment, the processor includes a graphical user interface (GUI).

In one embodiment, the central processor 203 transmits data wirelessly to the network 105. In another embodiment, the central processor 203 transmits data to the network 105 via a hardwire link. In still another embodiment, the central processor 203 processes raw data received from the field-positioned devices 206 and generates statistics based on that raw data. The central processor 203 transmits the statistics to the field-positioned devices 206. The central processor 203 further transmits voice or data messages to the field-positioned devices 206. The field-positioned devices 206 relay the messages to the specific player-mounted device 202. In another embodiment, the system 200 may send some or all of the player-mounted devices 202 the same message, such as "Race Over."

Figure 2B illustrates another embodiment of the system 200′ of the present invention. In this embodiment, medium 201′ is water. The water may be a lake, river, ocean, channel, or any suitable body of water. In one embodiment, the player-mounted device 202 is waterproof. In another embodiment, the player-mounted device 202 is waterproof to 300 meters below the surface of the water. In yet another embodiment, the player-mounted device 202 is adapted for use on the wrist of the player 216. In still another embodiment, the player-mounted device 202‴ is adapted for use in the goggles of the player 216. In this embodiment the player-mounted device 202‴ is adapted to display the data on the lens of the goggle while also allowing the player 216 to view the surrounding environment 201′.

At least one buoy 220 including a transceiver and an antenna 208 is located along the course. The buoy 220 functions as a field-positioned device 206 for the water. The buoy 220 is anchored to remain substantially stationary. In another embodiment, the buoy 220 is free to float with the tide. In yet another embodiment, a boat tows the buoy 220. In this embodiment, the player 216 swims past the buoy 220. As the player 216 reaches the buoy 220, data is both transmitted and received between the player-mounted device 220 and the transceiver within the buoy 220. In one embodiment, the data includes a distress signal sent by the player 216. The distress signal alerts nearby rescue boats that the player 216 is in trouble. In another embodiment, the player-mounted device 202 transmits data including water temperature to the buoy 220. In an alternate embodiment, the boat 218 is adapted to transmit and receive data in conjunction with the player-mounted device 202. Alternatively, a plurality of boats 218 is anchored along the course. Each boat 218 includes a field-positioned device 206. In another embodiment, boat 218 follows player 216 along the course.

Figure 2C illustrates an alternative embodiment of the system 200" of the present invention. In this embodiment, the medium 201" is snow. The player 216 is wearing skis 224. In one embodiment, the player 216 wears the player-mounted device 202 on her arm. In another embodiment, the player-mounted device 202" is mounted to one of the skis 224. In yet another embodiment, the player-mounted device 202"' is incorporated into goggles worn by the player 216. The performance data is displayed on at least one of the lenses of the goggles while allowing the user to simultaneously view the surrounding environment 201". The embodiment further includes field-positioned devices 222 located along the course. The field-positioned devices 222 include the transceivers as well as antennas 208. In another embodiment, snowmobiles (not shown) including field-positioned devices are located along the course.

In one embodiment, the position and performance information is transmitted to a central processor 203 which downloads the data to a database. In another embodiment, the information is adapted for viewing over the Internet.

Figure 3 is a block diagram of an illustrative player-mounted device 102 of the type employed in the performance monitoring system 100 of Figure 1. The player-mounted device 102 illustratively includes a processor 308, a transceiver 306, an antenna 302, a display 314, a digital memory 310, a data acquisition subsystem 312, a beeper/speaker subsystem 316, and a power source 320. Optionally, the illustrative player-mounted device 102 also includes control inputs and a voice actuated control/data input.

As mentioned above, the player-mounted device 102 monitors performance parameters in virtually any sport or recreational activity, including for example, running, skiing, swimming, baseball, hiking, sailing, rowing, basketball, hockey, ice skating, roller skating, skateboarding, soccer, football, tennis, boxing, martial arts, motor sports, horse racing, dog racing, track and field events, racquetball, squash, badminton, volleyball, tug-of-war, weight lifting, bodybuilding, paddleball, handball, and the like. In further embodiments, the player mounted device 102 can monitor military maneuvers. As also mentioned above, according to the illustrative embodiment, the player-mounted device 102 may be mounted in a variety of manners. By way of example, it can be mounted to a player's torso, head, neck, arm or leg. It may also be mounted to player apparel, such as a shirt, pants, padding, glove, helmet, saddle, shoe, skate, or the like. It may also be mounted to equipment, such as a goal, stick, racket, bat, ski, ski board, surf board, skateboard, or the like. It may also be mounted to a vehicle, such as a bicycle, motorcycle, car, airplane, boat, personal watercraft, snowmobile, or the like. In some embodiments, the player-mounted device 102 is referred to as a "player patch."

According to the illustrative embodiment, the antenna 302 is a 902-928 MHz antenna. The antenna 302 may be, for example, a patch antenna, a stub, or a dipole antenna. Other frequencies can, of course, be used depending on requirements. In a preferred embodiment, the player antenna 302 couples to a diplexer or switch. This coupling serves to isolate the transmit signals from the receive signals. In one mode of operation, the illustrative player-mounted device 102 transmits and receives information in half-duplex mode. In that embodiment, the transmit and receive modes are mutually exclusive and are individually software-controlled. In another mode of operation, the

player-mounted device 102 transmits and receives information in full-duplex mode. In this embodiment, the transmit and receive modes operate simultaneously.

The transceiver 306 down converts incoming radio frequency (RF) signals from the antenna 302 from 916 MHz to a baseband or intermediate frequency (IF) of 10.7 MHz. The signal is then demodulated into a corresponding bit stream by a demodulator. The transceiver 306 sends the bit stream to the processor 308. In one embodiment, the demodulator is included in a single-chip transceiver. One such player transceiver is the TRF6900 RF transceiver, available from Texas Instruments, Inc., Dallas, Texas. The illustrative player transceiver 306 further includes a direct digital synthesizer (DDS). The DDS acts as the local oscillator for both up- and down-conversion of the data signals

The processor 308 is adapted to perform a plurality of functions. For example, the processor 308 controls the operation of the transceiver 306. The processor 308 also interfaces to stored memory 310 to access stored information. The processor 308 is further adapted to receive data from the sensors and data acquisition block 312, and to format that data for transmission to the field-positioned device 104 according to a protocol or for the purposes of compression and/or error detection and correction. The processor 308 also interfaces to the display 314 and the beeper/speaker 316 subsystems. The display 314 and the beeper 316 subsystems are adapted to relay data to the user 216. The processor 308 further controls system timing, including a power saving sleep mode. In an alternative embodiment, the processor 308 also synchronizes received bit streams. The processor 308 also decodes and routes data. In another embodiment, the processor 308 performs compression, error detection and error correction. The processor 308 also organizes upstream data words into proper packet formats for modulation and transmission. Additionally, the processor 308 changes transmit and receive frequency by setting the DDS. In the illustrative embodiment, the processor 308 is an MSP430 micro-controller, manufactured by Texas Instruments, Inc., Dallas, Texas.

Illustratively, the digital memory subsystem 310 includes an electrically erasable programmable read only memory (EEPROM). By way of example, the EEPROM may store non-volatile information such as instructions to be executed by processor 308,

device, user, and/or event information. The memory 310 may also include random access memory (RAM) for the temporary storage of raw data, monitored parameters and other volatile data. In some embodiments, the memory subsystem 310 is integrated into the processor 308.

The sensor and data acquisition block 312 comprises sensors or modules for making measurements of interesting parameters. By way of example, the sensors may include a multi-axis accelerometer to measure and calculate acceleration, stride length, velocity, the force of an impact, such as boxer's punch; a gyro can be used to measure the rotation of a figure skater; the radial and axial forces to which a player, such as a race car or driver, are subjected; the bat speed of a baseball player, or the arm speed of a player, such as a pitcher or a quarterback. A heart sensor enables cardiac parameters such as heart rate to be measured. A temperature sensor can measure ambient air temperature or body temperature. A glucose sensor could be used to monitor blood glucose levels. A pressure sensor can be used to monitor, for example, the depth of the diver in diving or scuba events. An altimeter may be included to measure, the players altitude, for example, in mountain climbing events. As discussed briefly above, and as skilled practitioners will appreciate, many other sensing and monitoring devices can be employed in the data acquisition subsystem 312 to enable calculation of a variety of performance parameters. For example, the system 100 can measure and calculate blood pressure, speed, direction, rotation, strength, elapsed time, split time, hang time, heart waveforms, brain waveforms, ranking in a competition, and the like.

In one embodiment, the processor 308 receives data from the sensor and data acquisition block 312. The processor 308 processes the data. The player transceiver 306 transmits the processed data to the field-positioned device 104. In another embodiment, the player-mounted device 102 transmits raw data from the sensors to the field-positioned device 104. The field-positioned device 104 then processes the raw data. In another embodiment, the data acquisition sensors collect a portion of the raw data needed to measure performance parameters. In another embodiment, the player-mounted device 102 collects other data by interacting with the field-positioned devices 104. In other embodiments, the processor 308 processes the raw data to determine the performance

parameters for the player. In other embodiments, the field-positioned devices 104 perform the processing of some or all of the raw data. As the player 216 comes within communication range of a field-positioned device 104, the player transceiver 306 wirelessly transmits either the raw data, the performance parameters, or some combination of each to the field-positioned device 104 by way of the player antenna 302. According to one feature, the field-positioned device 104 transmits processed performance data back to one or more of the player-mounted devices 300. According to one feature the field-positioned device 104 can measure or calculate player position and transmit it back to the player-mounted device or to the system for display. According to one feature the player-mounted device 102 can transmit signals it receives to the field-positioned device 104 in raw format for additional processing to determine its precise position without large demands on the battery.

The player display 314 and the beeper/speaker 316 are optionally used to convey information to the player 216. For example, the player display 214 may display real time, along with split times and elapsed time; present rank in event, heart rate, force of impact, temperature, identification information, or other performance parameter or raw data. In another embodiment, the player display 314 displays performance parameters of either the player to which the device 102 is mounted or of other players as specified during setup of the system 100, and either received from the field-positioned devices 104 or derived internally. The display 314 may also display messages from officials, coaches, team doctors, administrators, spectators, and the like. In one embodiment, the player display 314 is an LCD dot-matrix addressable module. In the illustrative embodiment, the Varitronix COG-12264I^{2}C chip-on-glass LCD display module is used. Varitronix, of Hong Kong manufactures the illustrative player display 314. In another embodiment, the player display 314 is adapted to display both graphics and text. In alternate embodiments, the player display 314 is a monochrome or color display.

In the illustrative embodiment, the beeper/speaker 316 sounds an audible alarm at, for example, predefined checkpoints, at user settable times, or in response to the occurrence of user settable or predefined events. In one embodiment, the beeper is a piezoelectric buzzer. In another embodiment, the beeper is an audio transducer. In the

illustrative embodiment, the Star Micronics CUT or MZT series audio transducer is used. Star Micronics America, Incorporated of Edison, New Jersey manufactures the illustrative audio transducer 316.

In alternative embodiments, the beeper/speaker 316 is an audio speaker 316 enabling the processor 308 to generate synthesized voice, music, or other audible sounds. In yet another embodiment, the speaker 316 is integrated into a wireless headphone worn by the player 216. In a further embodiment, the headphone is hardwired to the player-mounted device 102. In a further embodiment, the headphone is used together with a microphone to allow the player to send and receive short voice messages. According to another embodiment, by sending a voice message through the speaker 316, an animal trainer can command an animal player to which the player-mounted device 102 is fastened.

The control/data input interface 320 enables a player 216 to input data into the processor 308. In one embodiment, the input interface 320 includes a microphone, the input data is audio in nature, and the processor 308 recognizes a limited set of audio commands. According to an alternative embodiment, the interface 320 includes an infrared port, adapted for communicating with a device having infrared transmission capabilities, such as a keyboard, laptop computer, personal digital assistant (PDA), electronic organizer, digital watch, or the like. In another embodiment, the infrared port communicates with the field-positioned devices 104.

The control input 318 illustratively is a pushbutton interface that enables the player 216 to perform certain functions such as, for example, activating the backlight, responding to questions, and selecting the information to be displayed on the display 314. In the preferred embodiment a single control is used to control functionality. This makes the player-mounted device 102 easy to use while the player is running, etc. More complex control and setup functions are then accomplished using the wireless link to a computer 104 or 106. In other embodiments, the player-mounted device 102 includes a plurality of control inputs 318. According to that embodiment, other advanced features such as back-lit illumination, and local time setting are available. Alternatively, the

control input 318 functions as a stopwatch control. In another embodiment, the control input 318 includes a miniature keypad. Optionally, the player can enter initial conditions, change the information displayed, send messages or respond to messages, and/or request additional performance parameters from the field-positioned devices 104.

The power source 320 supplies power to the various player-mounted device components. In one embodiment, the power source 320 employs a 3-volt lithium cell. In another embodiment, it employs one or more 1.5-volt alkaline cells. In one embodiment, the power source 320 includes a battery conditioning circuit to monitor, step-up, and regulate the output of a battery. Alternatively, the power source 320 includes a battery supervisory circuit. The battery supervisory circuit includes "low battery" and "fault" indicators. This signal is supplied to processor 308 to control its modes and the player can be notified of battery level or condition through either the display 314 or the beeper/speaker subsystem 316

As mentioned above, in some embodiments the player-mounted device 102 processes the raw data locally within processor 308 and displays processed data on player display 314, while in other embodiments the device 102 transmits the processed data to a field-positioned device 104. In yet another embodiment, the player-mounted device 102 includes a wireless communication link to a network. The wireless network link enables the player-mounted device 102 to transmit to and receive data from network devices 107-115 for viewing.

Figure 4A depicts a wrist-worn embodiment 400 of the player-mounted device 102. The wrist-worn embodiment 400 includes a display 314. The wrist-worn device 400 also includes a case 424 that houses the display 314, as well as some or all of the internal circuitry discussed above with respect to Figure 3. The case 424 is typically manufactured from metal or plastic. In alternate embodiments, the case 424 is sweat proof, waterproof, and shock resistant. In another embodiment, the case 424 includes a scratchproof transparent window through which the display 314 can be viewed. In yet another embodiment, the window is tinted and/or polarized to minimize glare. The case and band also provide mounting for the antenna used to send and receive signals.

The illustrative case 424 also includes pushbuttons 426a-426c. In one embodiment, each of the pushbuttons 426a-426c activates different modes of the wrist-worn device 400. In another embodiment, one of the pushbuttons 426a-426c illuminates the player display 425. As described above with respect to the control input 318, the pushbuttons 428a-426c individually and in combination can provide a plethora of functionality.

In another embodiment, the case 424 also includes at least one interface port 434. In exemplary embodiments, the interface port 434 provides at least one of an infrared port, a serial port, a keyboard/mouse port, a universal serial port (USB), or a printer port. Because of size constraints, wireless interfaces to the device are preferable (e.g., IEEE802.11, Bluetooth, BodyLAN, IRDA, etc.).

The wrist-worn device 400 further includes a strap 428 and a buckle 430 for attaching the device 400 to the arm of a player 216. In alternate embodiments, the strap 428 is manufactured from plastic, metal, leather, or any suitable synthetic or natural material. In alternative embodiments, the metal is titanium, steel, aluminum, gold, silver, platinum, or any suitable metal. In another embodiment, the strap 428 is a metal bracelet with a clasp. In another embodiment, the strap 428 is closed with Velcro.

Referring now to Figure 4B, therein is shown an alternative embodiment 314′ of the player display 314. Data shown in Figure 4B is related to the current date and time of day. The current date 402 is Friday the 18th. The current hour 404 is twelve o'clock. The current minute 406 is zero minutes. The current seconds 408 is eighteen seconds. The player display 314′ further indicates the morning or afternoon 410. In another embodiment, the player display 314′ can be displayed in 24 hour or military time format. In that case AM/PM indicator 410 is not displayed. In the preferred embodiment, the player display 400 includes a field for displaying text or graphical messages 412. The text or graphical messages 412 may be received, by way of example, from a field-positioned device 104, the central processor 106, other wireless device. In alternative embodiments, the player 216 optionally displays messages 412 to himself or herself on the player display 314′.

Figure 4C depicts another alternative embodiment 314" of the player display 314. Data shown in the display 314" is related to sample performance parameters. For example, the current position 414 of this player is 153rd place. The current elapsed hours 416 is two hours. The current elapsed minutes 418 is twenty-six minutes. The current elapsed seconds 420 is twenty seconds. Additionally, as shown at 422, the player 216 is averaging just over an eight-minute mile. As described above, virtually any parameter that can be monitored relating to an activity can be displayed in the player display 314.

Figure 5 illustrates a block diagram of an illustrative field-positioned device 104 of the type employed by the system 100 Figure 1. The field-positioned device 104 includes a transceiver 506, an antenna 502, a processor 508, and a power source 520. Alternate embodiments of the field-positioned device 104 include memory 510, a public display 514, a keyboard/mouse interface 512, a user display 526, a network connection 522, and a GPS receiver 524. In one embodiment, the antenna 502 is a dipole antenna. In another embodiment, the antenna 502 is flexible. In another embodiment, the antenna 502 is located remotely from the field-positioned device 104.

The field-positioned device 104 includes a transceiver 506. The transceiver 506 is coupled to antenna 502. In one embodiment, the field transceiver 506 includes a receiver section for receiving signals from the player-mounted device 102. The receiver section of the field transceiver 506 downconverts an incoming RF signal. A demodulator included in the receiver section demodulates the RF signal into a data bit stream corresponding to the originally transmitted signal. The field transceiver 506 routes the data bit stream to the processor 508.

In one embodiment, the processor 508 processes the data received from the player-mounted device 102. In other embodiments, the processor 508 prepares new requests for the player-mounted device 102, logs all player-mounted device 102 transactions, performs system housekeeping functions, processes data from the player-mounted device 102, and sends appropriate input to the public display 514 and the user display 526. In another embodiment, the processor 508 interprets raw data received from the data acquisition subsystem 312 of the player-mounted device 102. In yet another

embodiment, the processor 508 routes processed data to the field transceiver 506 for transmission to the player-mounted device 102. In other embodiments, the processor 508 is a PC-based computer system, a workstation, or a server. The field-positioned device 104 further includes a memory 510. The memory 510 is interfaced to the processor 508. In an alternate embodiment, the memory 510 is integrated into the processor 508. In alternate embodiments, the memory 510 comprises random access memory RAM, read only memory ROM, or a disk or tape drive.

The transceiver 506 includes a transmitter section. In one embodiment, the transmitter section includes a DDS. The DDS provides the carrier and determines the frequency of transmission to and reception from the player-mounted device 102. The transmitter section is coupled to the antenna 502. The antenna 502 sends the transmitted signal to the player-mounted device 102.

In another embodiment, the network further interfaces to a public display 514. The public display 514 is adapted to display statistical information, player position, player identification, messages, and the like. In one embodiment, the public display 514 is a computer monitor. In another embodiment, the public display 514 is a large scoreboard display interfaced to the processor 508. The system can recognize the player, update statistics, and display messages and statistics on the scoreboard for the player as he passes. For example, the players' name might be displayed so the crowd could cheer for the Marathon runner by name. In another embodiment, the field-positioned device 104 further comprises a user display 526. The user display 526 is adapted to display statistical information, player position, player identification, messages, and the like. In one embodiment, the user display 526 is a computer monitor.

The field-positioned device 104 further comprises a keyboard/mouse interface 512. The keyboard/mouse interface 512 is coupled to the processor 508. The interface 512 allows a user to input various parameters into the processor 508 or control its setup. For example, a user inputs parameters relating to configuring the system for specific events. In another embodiment, the interface 512 is integrated into the processor 508.

The field-positioned device 104 further comprises a power source 520. In one embodiment, the power source 520 is a battery. In another embodiment, the power source 520 is an alternating current (AC) source. In yet another embodiment, the power source 520 is a direct current (DC) source. In still another embodiment, the power source 520 comprises a solar cell. The power source is adapted to provide power to all active system components in the field-positioned device 104.

The field-positioned device 104 further includes an network link 522. The network link 522 is coupled to the processor 508. In one embodiment, the network link is adapted to allow users on the Internet to send messages to the player 216. The player 216 receives the message on the player-mounted device 102. The field-positioned device 104 transmits the message to the player-mounted device 102. In an alternate embodiment, the Internet link is adapted to allow system 100 to transmit data relating to an event to the Internet. Users logged onto the Internet can then view the data. In another embodiment, the network link allows data to be uploaded from the processor 508 to a local or remote server 107. In that embodiment, the server stores and processes the data. In an alternate embodiment, the remote server creates and serves dynamic web pages to Internet clients.

In one embodiment, the field-positioned device 104 further includes a GPS receiver 524. The GPS receiver 524 is coupled to the processor 508. Using orbiting satellites, the GPS receiver 524 can calculate its own position. The GPS receiver 524 is adapted to locate the field-positioned device 104, synchronize its clock to other field-positioned devices and send location data to the player-mounted device 102 or send location data to the central processor 106. In another embodiment, the GPS sends location data to the Internet via the Internet link 522.

Figure 6 is a block diagram of an illustrative central processor 106 of the type optionally employed in the performance monitoring system of Figure 1. The central processor 106 includes a transceiver 606, an antenna 211, a processor 608, and a database 610. Alternate embodiments of the central processor 106 include a user display 614, a keyboard/mouse interface 620, and an Internet link 622. In one embodiment, the antenna 602 is a monopole, patch or other largely omnidirectional antenna. In another

embodiment, the antenna 211 is flexible. In another embodiment, the antenna 211 is located remotely from the central processor 106.

The central processor 106 also includes a transceiver 606. The transceiver 606 is coupled to the antenna 602. In one embodiment, the transceiver 606 includes a receiver section for receiving signals from the field-positioned device 104. The receiver section of the transceiver 606 downconverts an incoming RF signal and a demodulator in the receiver section demodulates the RF signal into a data bit stream corresponding to the originally bit stream transmitted by the field-positioned device 104. This bit stream is routed to the processor 608.

In one embodiment, the processor 608 processes the data received from the field-positioned device 104. In other embodiments, the processor logs all player-mounted device 102 transactions, logs all field-positioned device 104 transactions, performs system housekeeping functions, processes data from the player-mounted device 102, processes data from the field-positioned devices 104, and sends appropriate input to the user display 614 or other networked display devices 107-115. In another embodiment, the processor 608 interprets raw data received from the data acquisition subsystem 312 of the player-mounted device 102. In yet another embodiment, the processor 608 routes processed data to the field-positioned device 104 for transmission to the player-mounted device 102. In other embodiments, the processor 608 is a PC-based computer system, a workstation, or a server. The central processor 106 further includes a database 610. The database 610 is interfaced to the processor 608. In an alternate embodiment, the database 610 is integrated into the processor 608. In alternate embodiments, the database 610 comprises random access memory RAM, read only memory ROM, or a disk or tape drive. Alternatively, the database 610 is a database server.

The transceiver 606 includes a transmitter section. In one embodiment, the transmitter section includes a DDS. The DDS acts as the local oscillator onto which is modulated baseband data from the processor 608 at the carrier frequency for transmission to the field-position device 104. The transmitter section is coupled to the antenna 602. The antenna 602 sends the transmitted signal to the field-positioned device 104.

In another embodiment, the processor 608 further connects to a user display 614. The user display 614 is adapted to display statistical information, player position, player identification, messages, and the like. In one embodiment, the user display 614 is a computer monitor running software that presents the data interactively. In another embodiment, the user display 614 is a flat screen display.

The central processor 106 further comprises a keyboard/mouse interface 620. The keyboard/mouse interface 620 is coupled to the processor 608. The interface 620 allows a user to input various parameters into the processor 608. For example, a user inputs parameters relating to configuring the system for specific events or queries the system for status and health data. In another embodiment, the interface 620 is integrated into the processor 608.

The central processor 106 further includes an LAN or WAN (Internet) link 622. The Internet link 622 is coupled to the processor 608. In one embodiment, the network link to adapted to allow users on the network to send messages to the player 216. The player 216 receives the message on the player-mounted device 102. The central processor 106 transmits the message to the field-positioned device 104, which transmits the message to the player-mounted device 102. In an alternate embodiment, the network link is adapted to allow the central processor 106 to transmit data relating to an event to the Internet. Users logged onto the Internet can then view the data. In another embodiment, the network link allows data to be uploaded from the processor 608 to a local or remote server 107. In that embodiment, the remote server stores, processes, and serves the data. In an alternate embodiment, the remote server hosts the Internet site containing the processed data.

One embodiment of the operation of the system 100 is as follows. An event includes a sporting event, such as baseball, football, soccer, hockey, track and field, a marathon, a triathlon, boxing, karate, swimming, skating, cycling, racing, and wrestling, for example. At event also includes recreational events, such as hiking, climbing, hunting, bungee jumping, and walking, for example.

In the initial stage of an event, a database 610, located in the field-positioned device 104 or, alternatively, in the central processor106, relates each specific player-mounted device 102 to the user 216 wearing it. The player-mounted devices 102 are linked in the database 610 to pertinent user information (e.g., athlete's name, vital statistics, historical performance information, etc.). The user information is either soft- or hard-coded into the player-mounted device 102 or it may be looked up in a database using the player's ID.

The central database 610 links all field-positioned device transactions from every field-positioned device 104. In one embodiment, the linking is done in real-time. In another embodiment, the database 610 continuously monitors traffic to insure that only a single field-positioned device 104 interacts with a particular player-mounted device 102 at any given time. In another embodiment, the database 610 acts as a dispatcher. In that embodiment, the database 610 assigns the player-mounted device 102 to a particular field-positioned device 104, based on its proximity to that field-positioned device 104. The proximity is derived from triangulation or other means known to those skilled in the art. In another embodiment, positional information of the player-mounted device 102 is derived using the triangulation or multilateration method. In one embodiment, the triangulation method entails positioning a suitable number of field-positioned devices 104 at various locations around the course. The location of the player-mounted device 102 is calculated based on the its position relative to the field-positioned devices 104. In another embodiment, positional information is derived through GPS circuitry integrated into the player-mounted device 102.

In one embodiment of the system 100, a player 216 wears the player-mounted device 102. The player 216 passes near field-positioned devices 104. As the player 216 nears a field-positioned device 104, data is exchanged wirelessly between the player-mounted device 102 and the field-positioned device 104. The field-positioned devices 104 can be located at mile splits, kilometer splits, or at other intervals convenient to the user or event. In another embodiment, the field-positioned devices 104 are water stations.

In one embodiment, the player-mounted device 102, appears to be a watch or tag. The device 102 has standard runner's watch features like split or lap time, time of day, date, year, elapsed time, countdown timer, date, day of week, alarm, target split, back light, intervals, and 12/24 hour mode, for example. For sports such as triathlons, data can be tagged. By tagging data, events with multiple sub-events can be effectively monitored. For example, one group of data applies to running, a second group applies to swimming, and a third group applies to the bicycling portions of the event. The device 102 watch can optionally display graphical data, such as simple bitmaps, or graphs showing data trends that indicate whether a user is gaining in the race or falling back. In alternate embodiments, the graphical data or graphs are displayed either on the device 102, by means of a separate display, as audio signals, or via a virtual reality headset, for example.

The player-mounted device 102 can optionally include heart rate monitoring circuitry for receiving, processing, and display of heart rate data. Such circuitry includes heart rate, time spent above, below and within target heart rate, average and maximum heart rate, and recovery time. Additionally, the player-mounted device 102 can include altitude monitoring circuitry or barometric pressure reading circuitry. Furthermore, the player-mounted device 102 can include temperature or compass circuitry. In addition, the player-mounted device 102 can include pedometer monitoring circuitry, *i.e.* stride length, strides/second and accelerometers and/or gyros for measuring the smoothness of stride. Also, the player-mounted device 102 can include inputs for bicycle sensors, such as wheel rotations. One skilled in the art will appreciate that other sensors and monitors not mentioned could be integrated into the player-mounted device 102.

In another embodiment, memory 310 is provided to store data gathered by the player-mounted device 102. The data can be downloaded to the field-positioned devices 104 or viewed on the display 314. For example, the player-mounted device 102 stores lap times for *n* laps. In one embodiment, the player-mounted device 102 switches between two or more time zones. In another embodiment, the player-mounted device 102 is adapted to download alphanumeric messages, graphical, or audio messages to the

runner. For example, the player-mounted device 102 scrolls the message "Good Job" from supporters following along on the Internet.

In one embodiment, the player-mounted device 102 has a non-volatile memory that stores the player's identification, such as number, name, age, and weight. The display 314 optionally shows the player's place within a specified category (*i.e.* wheelchair or age group), and/or her overall place. The player-mounted device 102 also has a wireless link for uploading all the settings and all the information to be displayed and for downloading information from the player-mounted device 102. The wireless link includes the ability to set the local time in the player-mounted device 102. The transmitted data is formatted in such a way so as to avoid collisions with other player-mounted devices 102. Data from many player-mounted devices 102 is transmitted simultaneously and decoded properly at a specific field-positioned device 104.

In another embodiment, the player-mounted device 102 contains a wireless link which transmits the player's position information. In one embodiment, this is achieved via multilateration. The player-mounted device 102 also contains a wireless link which may be interfaced to a vehicle mounted unit (not shown) for longer distance signal transmissions. Alternatively, the player-mounted device 102 displays the position of other players in the event. This feature is useful to determine what position each player is currently in or to locate friends or competitors.

In alternate embodiments, the locations, shapes, and sizes of buttons, and the size and shape of the display and display graphics are ergonomically designed for ease of use. In one embodiment, the player-mounted device 102 is adapted to send data by selecting from a list of pre-entered messages, in a manner similar to 2-way pagers. For example, the player may send an Internet a message to supporters, such as "I'm doing well." The player-mounted device 102 also provides feedback to the user via sound, vibration, or visual indicators.

In one embodiment, the system 100 of the present invention also comprises display software included in the processor 608 and a database 610. The database 610 provides storage for all data. The processor 608 provides a display of the positions of all

the players in the event. This processor 608 can provide a snapshot, an animated recreation, or can display data in real-time. The software also provides a graphical output to the Internet or broadcast television. The software can also output statistics and/or graphics to data feeds such as SportsTicker™, or to pagers, for example. In another embodiment, the software provides output data to a satellite or cable television system.

The software contains analysis algorithms that can be applied to the data, as well as means for calculating and transmitting data to the field-positioned device 104. The field-positioned device 104 then transmits the data to the player-mounted devices 102. The software allows Internet users to send data to players and to receive data from players. Reports are provided to players at the end of the race in hardcopy or electronic format.

Having described and shown the preferred embodiments of the invention, it will now become apparent to one of skill in the art that other embodiments incorporating the concepts may be used and that many variations are possible which will still be within the scope and spirit of the claimed invention. It is felt, therefore, that these embodiments should not be limited to disclosed embodiments but rather should be limited only by the spirit and scope of the following claims.

What is claimed is:

1. A performance monitoring system comprising,

a first player-mounted device including,

a sensor adapted to automatically collect first player sensor data from said first player, and

a player transceiver adapted to wirelessly transmit and receive information, and

a first field-positioned device adapted to be located in a first stationary position and including,

a field transceiver adapted to receive at least one of said first player sensor data and said performance parameters, and to transmit at least one of said performance parameters and a message to at least said first player-mounted device.

2. A performance monitoring system according to claim 1, wherein said first player-mounted device further includes a display adapted to display said performance parameters to said first player.

3. A performance monitoring system according to claim 1, wherein said first field-positioned device further includes a field processor adapted to process said first player sensor data to generate said performance parameters.

4. A performance monitoring system according to claim 3, wherein said field processor is further adapted to process time information with said first player sensor data to generate said performance parameters.

5. A performance monitoring system according to claim 1, wherein said first field-positioned device is further adapted to detect a time at which said first player passes a predefined landmark.

6. A performance monitoring system according to claim 1, wherein said first player-mounted device is further adapted to detect a time at which said first player passes a predefined landmark.

7. A performance monitoring system according to claim 3 further comprising,

a central processor having a database and adapted to perform at least one of collecting, storing and distributing at least one of said first player sensor data and said performance parameters, and wherein said field transceiver is further adapted to transmit said performance parameters to said central processor.

8. A performance monitoring system according to claim 7 further comprising,

at least one of a Web server, a Web client, a video game client, a wireless client, a scoreboard indicator, a printer, a scoreboard display, and a television client, coupled to a network and adapted to provide said performance parameters to a network user, and wherein said central processor is further adapted to upload said performance parameters to said network.

9. A performance monitoring system according to claim 1, wherein said first field-positioned device connects via a communication network with a display adapted to display said performance parameters to spectators.

10. A performance monitoring system according to claim 1 further comprising,

a central processor adapted to process said first player sensor data to generate said performance parameters and including a database adapted to aggregate at least one of said performance parameters and said first player sensor data, and

said field transceiver is further adapted to transfer said first player sensor data to said central processor.

11. A performance monitoring system according to claim 10 wherein said central processor facility is further adapted to provide said field-positioned device with said performance parameters.

12. A performance monitoring system according to claim 10 wherein said first field-positioned device connects via a communication network with a display adapted to display said performance parameters to spectators.

13. A performance monitoring system according to claim 10 further comprising,

at least one of a Web server, a Web client, a video game client, a wireless client, a scoreboard indicator, a printer, a scoreboard display, and a television client, coupled to a network and adapted to provide said performance parameters to a network user, and wherein said central processor is further adapted to upload said performance parameters to said network.

14. A performance monitoring system according to claim 1, wherein said first player-mounted device further includes a display device adapted for displaying a selected portion of said performance data to said first player.

15. A performance monitoring system according to claim 1, wherein said sensor is adapted to sense at least one of a heart characteristics of said first player, brainwave characteristics of said first player, body temperature of said first player, blood pressure of said first player, blood sugar level of said player, an air temperature, and an atmospheric pressure.

16. A performance monitoring system according to claim 1, wherein

said first player-mounted device further includes at least one accelerometer adapted to measure at least one of an acceleration of said first player, a stride length of said first player, stride rate of said first player, a velocity of said player, and an impact of with said player, and to generate first player sensor data indicative thereof.

17. A performance monitoring system according to claim 1, wherein

said first player-mounted device further includes at least one gyroscope adapted to measure a rotational acceleration of said first player-mounted device, and to generate first player sensor data indicative thereof.

18. A performance monitoring system according to claim 1, wherein

said first player-worn device further includes at least one accelerometer adapted to measure an acceleration resulting from an impact, and said system is further adapted to calculate a force of said impact.

19. A performance monitoring system according to claim 1 further comprising,

a second player-mounted device including,

a sensor adapted to automatically collect second player sensor data from said second player, and

a player transceiver adapted to wirelessly transmit and receive information, and

a second field-positioned device adapted to be located in a second stationary position and including,

a field transceiver adapted to receive at least one of said first player sensor data, said second player sensor data, and said performance parameters, and to transmit at least one of said performance parameters and a message to at least one of said first and said second player-mounted devices, and wherein

said performance parameters include performance parameters associated with at least one of said first player and said second player.

20. A performance monitoring system according to claim 19 further comprising,

a central processor adapted to process at least one of said first player sensor data, said second player sensor data, said performance parameters, and time information to determine a first time for said first player to traverse a distance between two predefined landmarks.

21. A performance monitoring system according to claim 20, wherein said central processor is further adapted to process at least one of said first player sensor data, said

second player sensor data, said performance parameters, and time information to determine a second time for said second player to traverse a distance between two predefined landmarks.

22. A performance monitoring system according to claim 21, wherein said central processor is further adapted to process said first time and said second time to determine a relative time ranking between said first and said second players.

23. A performance monitoring system comprising,

a first player-mounted device including,

a data sensor adapted to automatically collect first player performance from said first player,

a player processor adapted for processing said first player performance data, and

a player transceiver adapted to wirelessly transmit and receive information, and

a first field-positioned device adapted to be located in a first stationary position and including,

a field transceiver adapted to receive said processed first player performance data transmitted from said first player-worn device, and to provide messages to said player transceiver.

24. A performance monitoring system according to claim 23 further comprising,

a second player-mounted device including,

a sensor adapted to automatically collect second player performance data from said second player,

a player processor adapted to process said second player performance data, and

a player transceiver adapted to wirelessly transmit and receive information, and

a second field-positioned device adapted to be located in a second stationary position and including,

a field transceiver adapted to receive said first and said second player processed performance data, and to transmit at least one of a portion of said first and said second player processed performance data, and messages to at least one of said first and said second player-mounted devices, and

wherein, said transceiver of said first field-positioned device is further adapted to transmit at least one of a portion of said first and second player processed performance data, and messages to at least one of said first and second player-mounted devices.

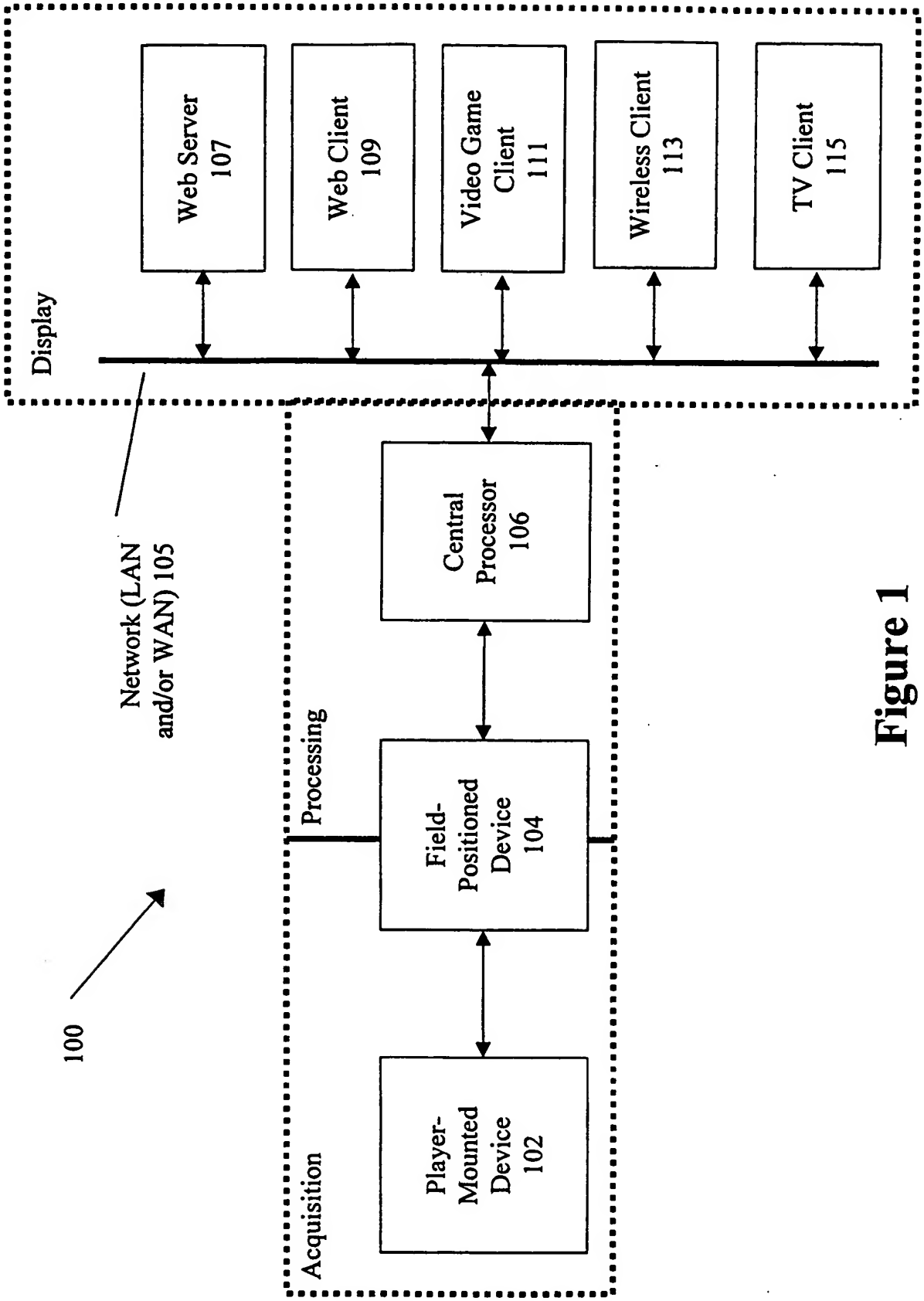
Display
Web Server 107
Web Client 109
Video Game Client 111
Wireless Client 113
TV Client 115
Network (LAN and/or WAN) 105
Central Processor 106
Processing
Field-Positioned Device 104
Player-Mounted Device 102
Acquisition
100

Figure 1

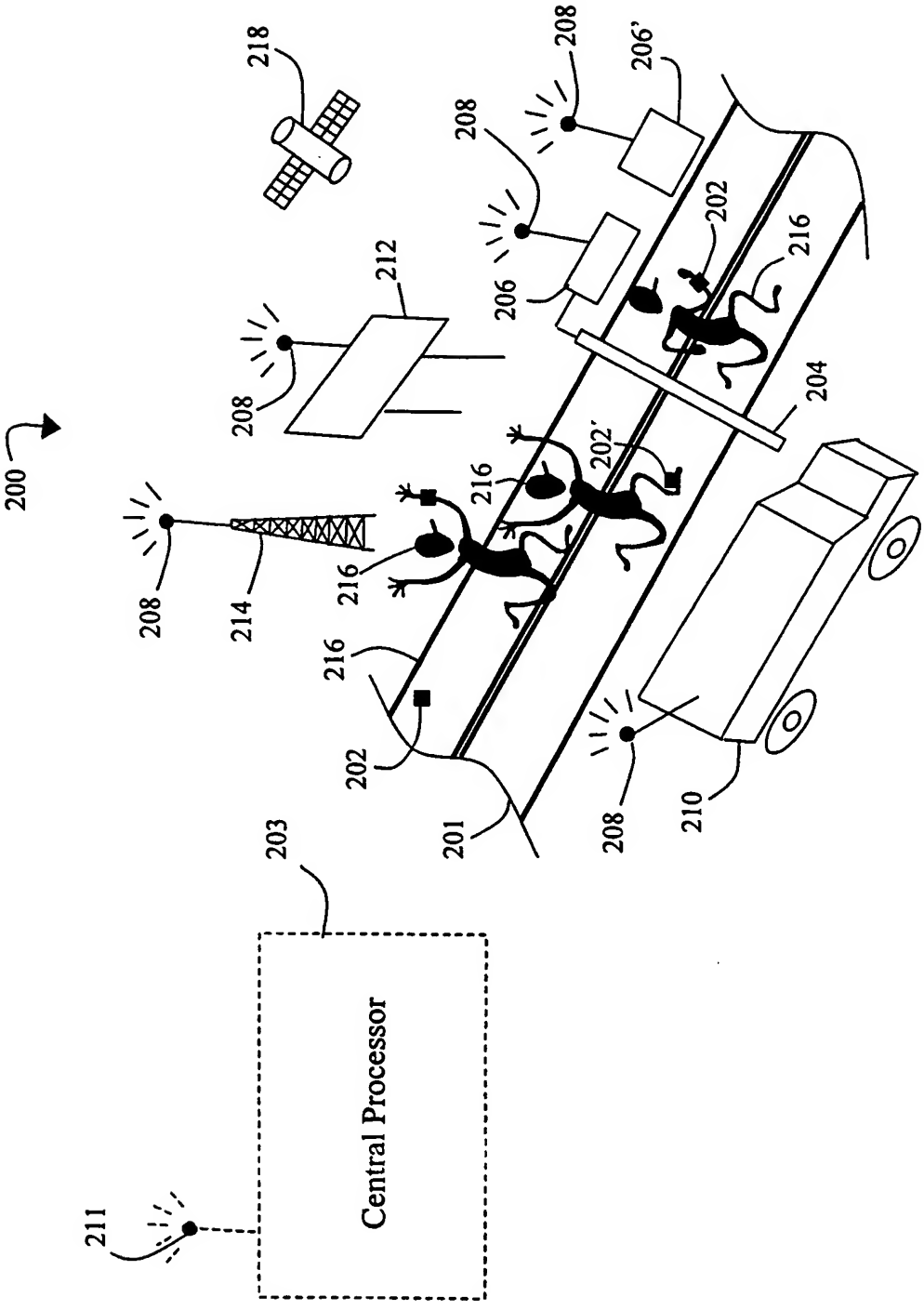
200
201
202
202'
203
204
206
206'
208
210
211
212
214
216
218
Central Processor

Figure 2A

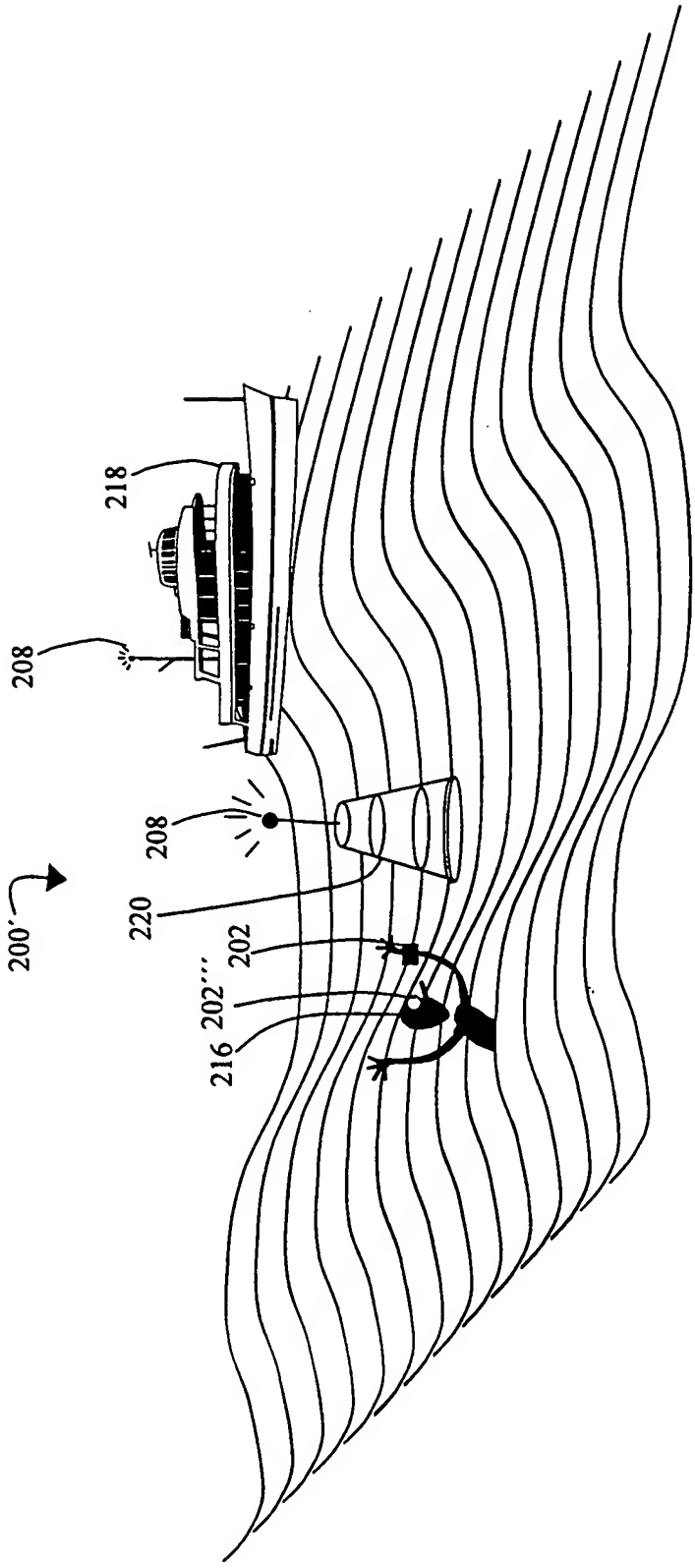

Figure 2B

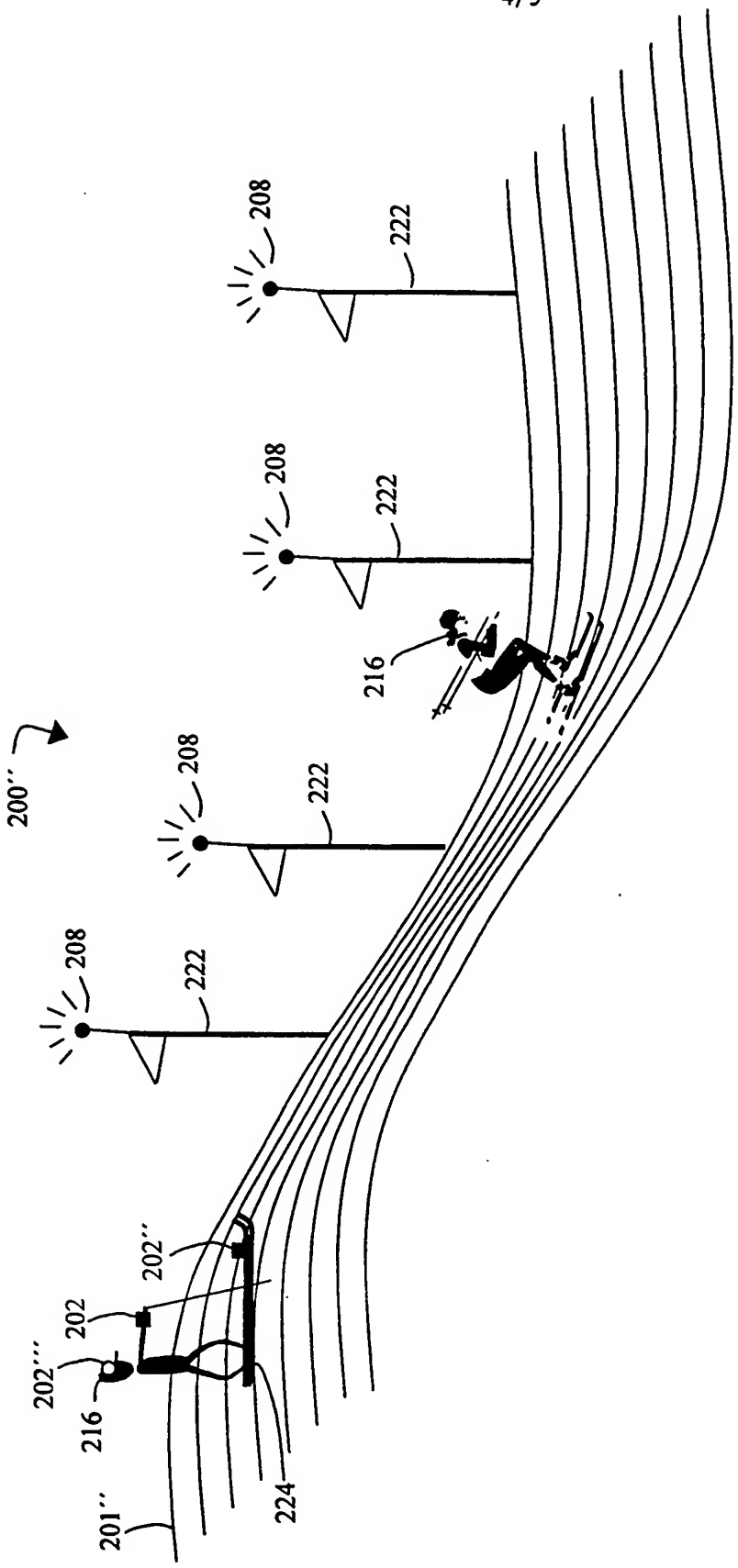

Figure 2C

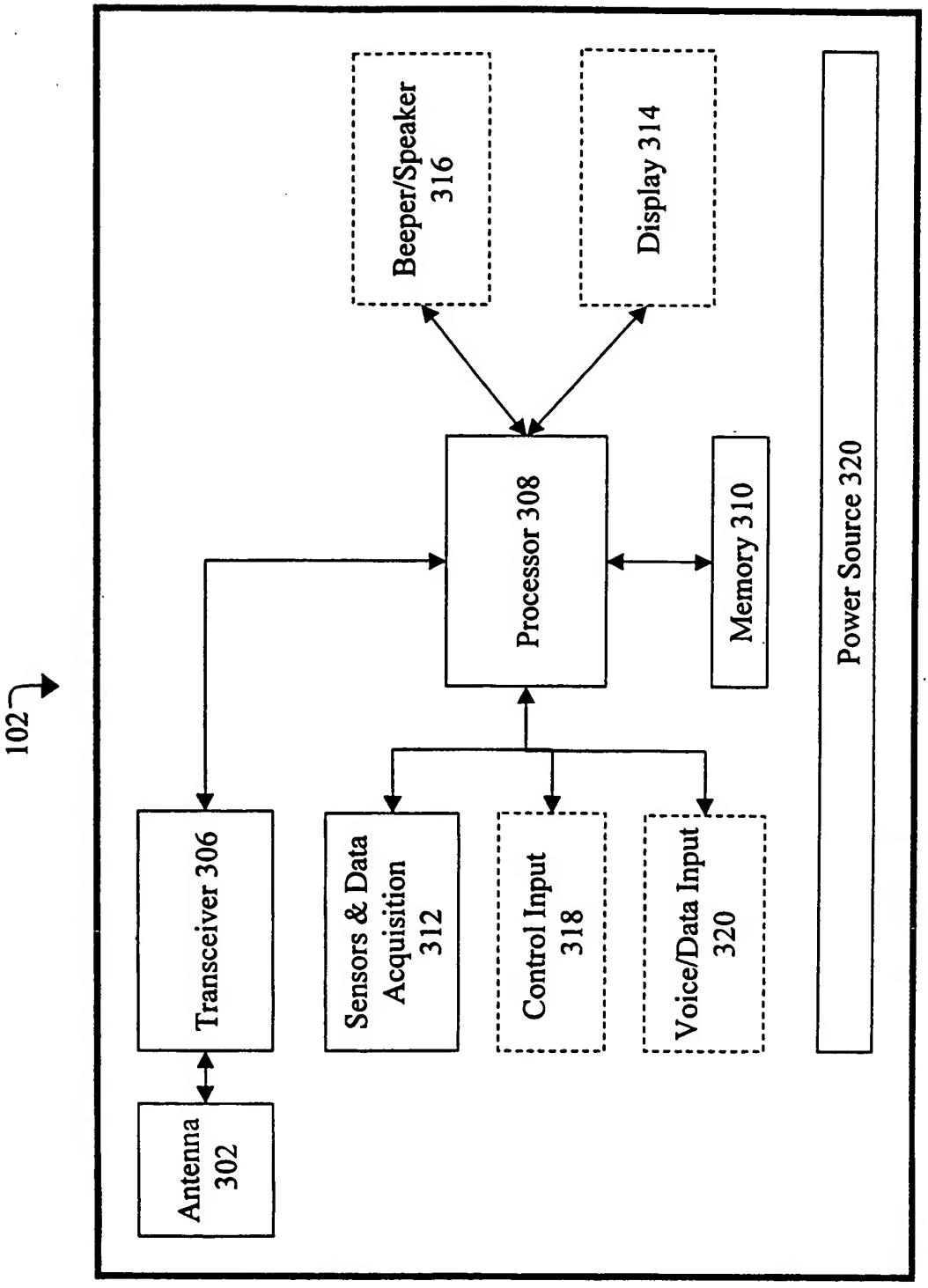
102
Antenna 302
Transceiver 306
Sensors & Data Acquisition 312
Control Input 318
Voice/Data Input 320
Processor 308
Memory 310
Beeper/Speaker 316
Display 314
Power Source 320

Figure 3

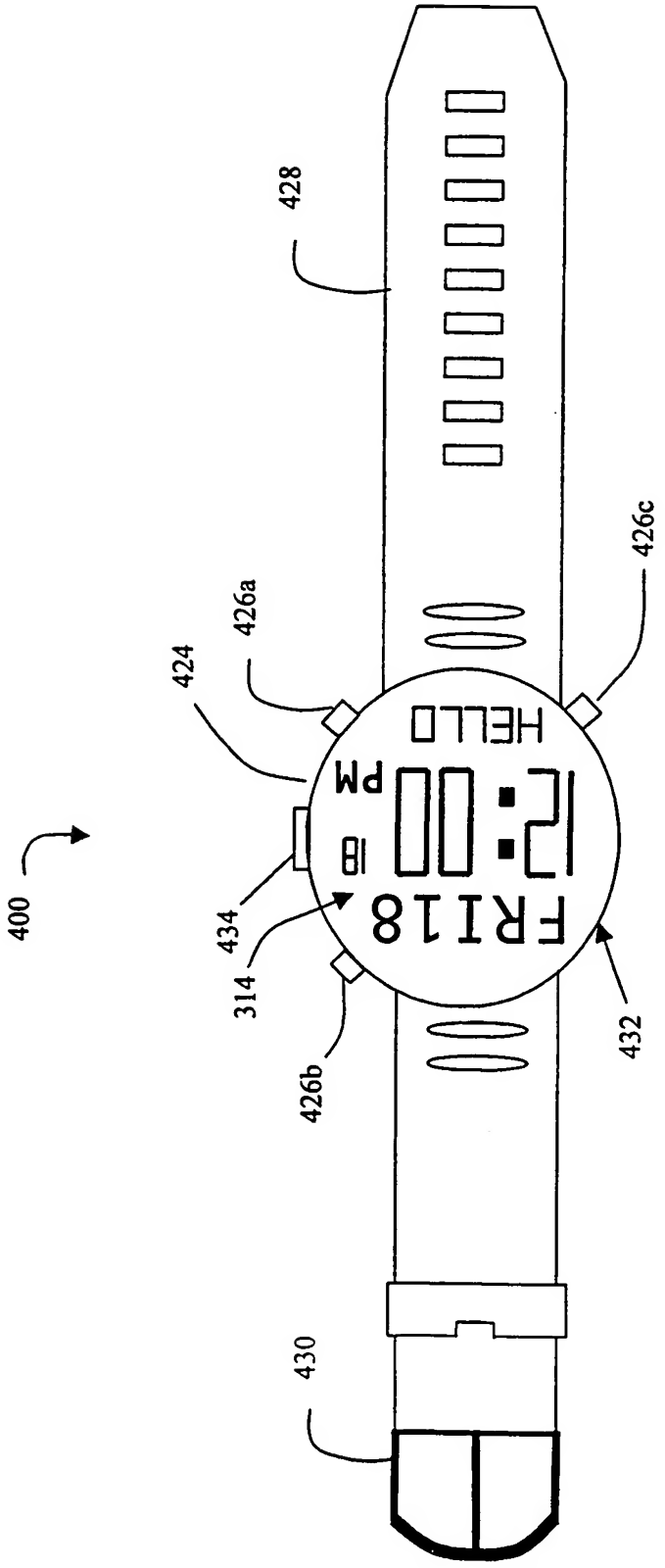

Figure 4A

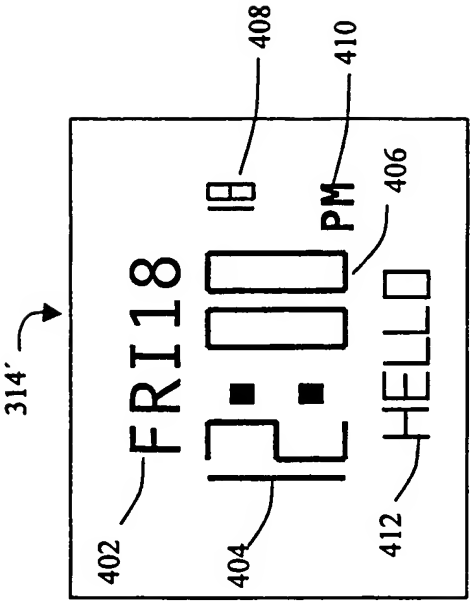

Figure 4B

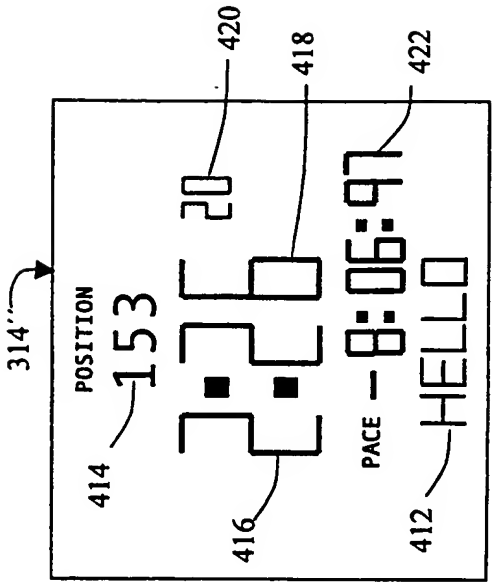

Figure 4C

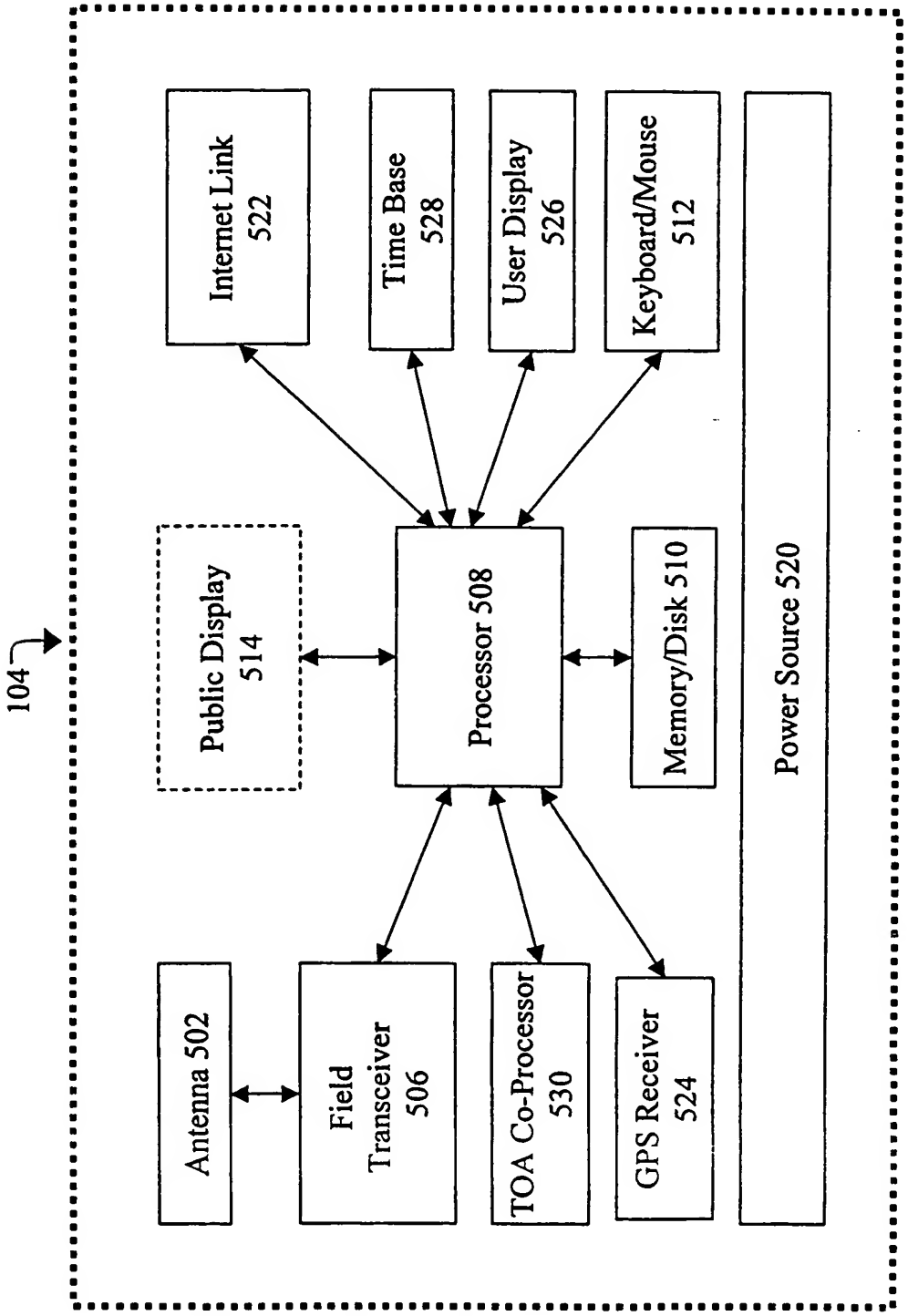
104
Internet Link 522
Time Base 528
User Display 526
Keyboard/Mouse 512
Public Display 514
Processor 508
Memory/Disk 510
Power Source 520
Antenna 502
Field Transceiver 506
TOA Co-Processor 530
GPS Receiver 524

Figure 5

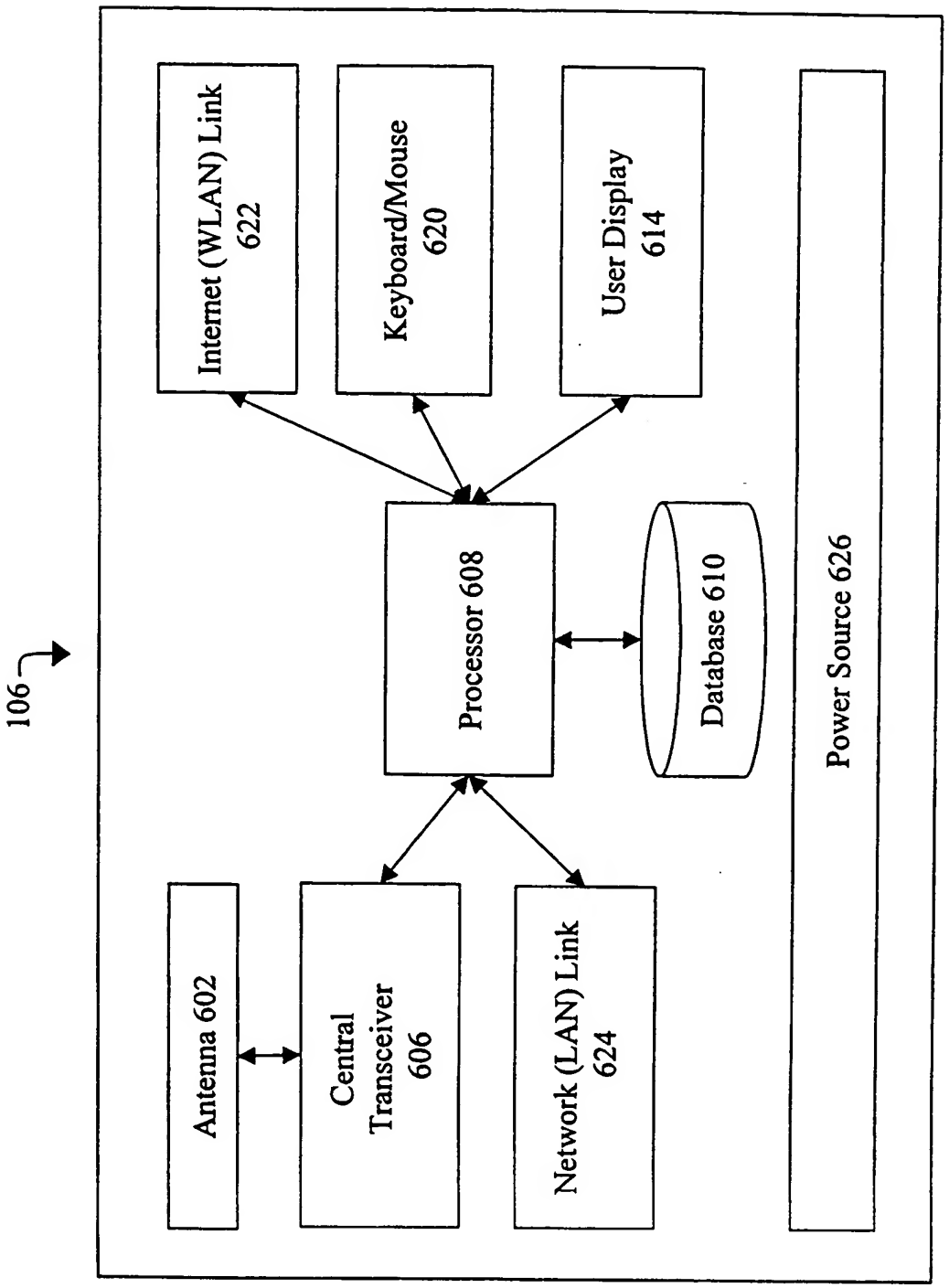
106
Internet (WLAN) Link 622
Keyboard/Mouse 620
User Display 614
Processor 608
Database 610
Power Source 626
Antenna 602
Central Transceiver 606
Network (LAN) Link 624

Figure 6

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(71) Applicant: TRAKUS, INC. [US/US]; Suite 112, 35 Medford Street, Somerville, MA 02143 (US).

(72) Inventors: WADELL, Brian, C.; 73 Mount Vernon Street, Reading, MA 01867 (US). SPITZ, Eric; Apartment 24, 269 Harvard Street, Cambridge, MA 02139 (US). KATZ, David, J.; 2602 Village Road West, Norwood, MA 02062 (US).

(74) Agent: GIANNETTA, Michael, J.; Testa, Hurwitz & Thibeault, LLP, High Street Tower, 125 High Street, Boston, MA 02110 (US).

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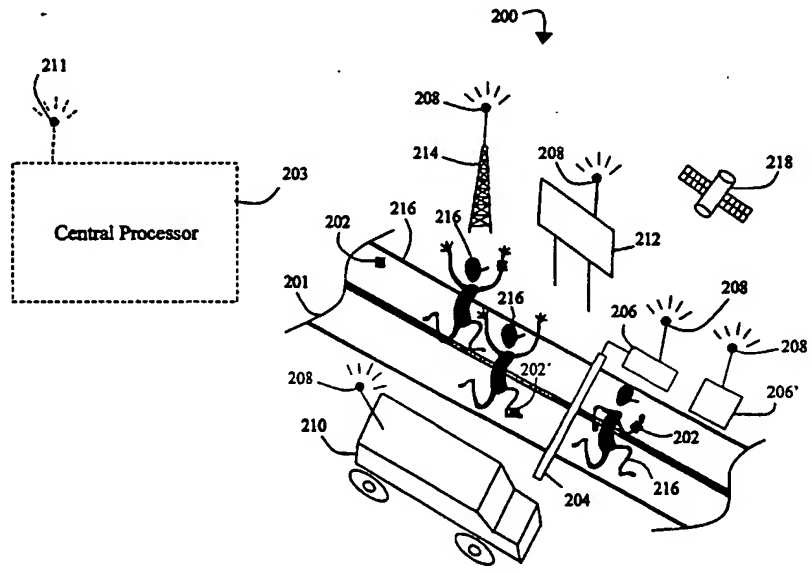
(54) Title: PERFORMANCE MONITORING SYSTEM



(57) Abstract: The invention, in one embodiment, is directed to a performance measurement system comprising a first player-mounted device and a first field-positioned device. The first player-mounted device includes sensors adapted for automatically collecting sensor information from the first player, and a player transceiver adapted to wirelessly transmit and receive information. The first field-positioned device is adapted to be located in a first stationary position and includes, a field transceiver adapted to receive at least one of the first player sensor data and the performance parameters, and to transmit at least one of the performance parameters and messages to the first player-mounted device. In other embodiments, the system includes display devices and a central processor.

WO 01/00281 A3

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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A63B G07C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	US 5 737 280 A (KOKUBO) 7 April 1998 (1998-04-07) the whole document	1-16, 19-24
X A	US 5 524 081 A (PAUL) 4 June 1996 (1996-06-04) column 5, line 36 -column 8, line 50; figures 1-7	1-4,7,8, 23 5,6, 9-14, 19-22,24

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
22 December 2000	04/01/2001

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European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Williams, M

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Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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